ATMOSPHERIC ELECTRICITY.

At the present time there is no satisfactory theory of the source of atmospheric electricity. Many believe, in the absence of positive evidence of the production of electricity by the operation of evaporation and condensation, that the earth has a definite charge, which resulted from the operations at its birth, and which it has kept undiminished in amount; and that thunder-storms are merely the expression of local accumulation due to currents of air.

Mr. G. Le Goarant de Tromelin, in a late number of the *Comptes rendus*, advances the opinion that atmospheric electricity is due to the friction of the air, humid or dry, upon the surface of land or water, and calls attention to Armstrong's hydro-electric machine, which produced electricity of high tension by the friction of jets of steam in issuing from narrow orifices. According to Tromelin, the wind, in skimming over the surface of water, carries water from the crests of the waves, which play the part of the comb of Armstrong's machine. The roughness of the soil does the same on land when a damp wind passes over it. The charge thus produced is collected upon the vesicles of clouds. The potential energy of a cloud depends upon its configuration and its temperature. If this configuration changes under the effect of condensation or congelation of the aqueous particles, the cloud absorbs a certain amount of energy, which must be found again under the form of an augmentation of potential energy: hence there is an electrical interchange constantly going on in the cloud region of the air; and when these changes are rapid, and great in amount, we have thunder-storms and other great electrical manifestations.

The advocates of Mr. Tromelin's views can point to the effect of the blasts of sand driven by the wind upon the pyramids, and to the extraordinary electrical manifestations upon high peaks in Colorado, where every *aiguille* seems to hiss, at times, with the escaping electrical charge.

We believe that the time has arrived when the scientific world no longer looks upon electrical phenomena as isolated and separate from the phenomena of heat and light, or chemical reactions. We cannot believe that any change can take place in the arrangement and mutual attractions of molecules without electrical manifestations. If we are to have a thermal chemistry, we must also have an electrical chemistry; and the history of the energy of a chemical reaction is not completely told when we sum up the heat of this reaction, unless we count also the heat-equivalent of the resulting electrical changes. If we were, therefore, to frame a theory of atmospheric electricity, we should begin it with the assertion that every change in the configuration or arrangement of particles of matter is accompanied by an electrical disturbance; and, as far as this assertion goes, all the present theories of atmospheric electricity would fall under it as special cases.

The object of this paper, however, is not to frame hypotheses, but to trace the recent work which has been done in systematic observation of atmospheric electricity. It is only to systematic observation that we can evidently look for information which will be of immediate practical value to our signal-service. Unfortunately, no systematic observations have been made for any length of time in any country.

The electrical conference at Paris, held last April, was adjourned from a meeting of the previous year; and committees were appointed to study the subject of atmospheric electricity and earth-currents in different countries. The time was evidently too short for such a stupendous undertaking; but the conference did valuable work in stimulating systematic observation, and creating a bureau at Berne, to which it was recommended that observations made in different countries should be sent. The agitation of the subject of such observations called forth several papers. Professor Ròiti of Florence presented to the conference the result of observations made through several months with a self-registering apparatus. He found that the zero of Mascart's electrometer changed from time to time, and traced this change to the mechanical effect of the sulphuric acid upon the platinum wire connected with the electrometer needle. He therefore dispensed with the Leyden jar of the Thomson and the Mascart electrometer, and suspended the needle by a very fine silver wire which was connected directly to the positive pole of a water-battery of many cells. This instrument was found to work well. Professor Ròiti believes that local disturbances have great effect, and that these local effects must be carefully taken into account in comparing simultaneous observations over large areas.

Athough the scientific world has generally accepted Thomson's quadrant electrometer, or some modification of it (like that of Mascart's or Clifton's), as the most suitable instrument for the observation of atmospheric electricity,

and has also adopted Thomson's water-dropper (which consists merely of an insulated can of water connected with the quadrants of the electrometer, the water issuing from this can in small drops, reducing it to the potential of the air), still there are those who believe that this method does not give correct results. Professor Palmieri, who has been connected so long with the meteorological stations on Mount Vesuvius, rejects Thomson's electrometer, and the water-dropper also. He believes that the electricity of the air is not led to the water-dropper by conduction, and that the insulated water-can does not take the electricity of the air by any similar process. According to his views, the electrical state of the air can be ascertained by its inductive effect upon a disk of metal which is suddenly elevated or lowered in the air; and he has devised a special electrometer, strongly resembling Peltier's electrometer, and a special apparatus for elevating and lowering a disk. He, moreover, does not think that continuous photographic registrations are of much use, since electrical observations are only of value when accompanied by observations on the condition of the sky with respect to clouds, and upon the direction of the wind.

Professor Palmieri's methods and instruments do not impress us very favorably. There must be great difficulty in insuring good insulation by his method of suddenly elevating a disk in the air. Moreover, his theory of induction does not appear to us to be well founded. The Thomson method of observing atmospheric electricity seems to promise better results than any other; yet it is not by any means perfect, especially in its practical adaptation to the needs of a government signal-service. The experiments which are being conducted at the physical laboratory of Harvard college show that in the American climate it is extremely difficult to secure a regular flow of water from the water-dropper, and to obtain good insulation, on account of frost and snow. During the months which are free from snow and ice, heavy showers wet the insulating stand of the water-dropper, and thus destroy the insulation. The latter evil can be obviated to some degree by a well-constructed screen of wood. It has been found preferable to neglect the insulation of the can, and allow the drops of water to fall upon a metallic plate, thrust out from the side of the room in which the electrometer is situated, by means of a glass cylinder through the centre of which runs a wire which connects the metallic plate with the electrometer. The drops of water fall, in turn, from the metallic plate, and reduce this to the potential of the air, while the insulation of the metallic disk can be perfectly maintained in all weathers. Preliminary experiments have also been made upon an arrangement which promises to be of use in winter, when the weather would prevent the use of the water-dropper. This arrangement consists merely of a wheel provided with metallic brushes. The wheel is run rapidly by simple clock-work, and is insulated. The brushes touch one end of an insulated conductor exposed to the air, and then touch a conductor connected with the earth, in this way imitating the action of the water-dropper. An arrangement of this kind, which will work in all changes of weather, is essential in the climate of the United States.

The preliminary experiments at the laboratory of Harvard college have also shown that it is essential that the electrometer should not be very distant from the water-dropper or its equivalent. A naked iron wire connected the electrometer with a water-dropper which was about three hundred feet distant at the top of a building, and at least sixty feet from the ground. The photographic record of the excursions of the electrometer needle showed that it moved irregularly to and fro under the influence of the fluctuation of potential along the wire. There is evidently a certain relation between the size of the conductor, which is reduced to the potential of the air by the succession of water-drops, and the number of orifices from which the water must issue in order to reduce the conductor and connecting wire to the potential of the air.

The photographic records that have been made show unmistakably that north-west winds in the colder months are preceded by a rise in the electrical potential of the air, and that during an east wind the potential falls. These general indications seem to be independent of local effects, and lead us to believe that electrical signal-station observations will be useful in predicting changes of weather. Photographs of the varying electrical state of the air could be forwarded to Washington from different stations, and a map could be made on which stations at the same electrical potential could be connected; and thus any law connecting the electrical state of the atmosphere with other meteorological changes could probably be ascertained. Much remains to be done, however, in ascertaining the best position for such signal-stations, and in perfecting simple and practical apparatus for the use of comparatively unskilled observers.

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